

Thickness Dependence of PtMn Chemical Order in PtMn Spin Valves

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Introduction: The present generation of magnetic recording heads for disk drives use giant magnetoresistive (or spin valve) read sensors consisting of multilayers of thin films with typical structures of [1]: ferromagnetic-layer: spacer-layer: ferromagnetic-layer: antiferromagnetic-layer. In these structures there is an exchange bias across the antiferromagnetic-ferromagnetic interface that plays a key role in the spin valve sensors. Various antiferromagnetic alloys and compounds have been used as exchange biasing layers, but recent interest has focused on PtMn and NiMn [1-3], since these exhibit higher blocking temperatures (where the exchange drops to zero) and are more corrosion resistant than other materials. The antiferromagnetic phase of both NiMn and PtMn is a chemically ordered $L1_0$ type structure, while in the disordered fcc phase is not antiferromagnetic.

Results: Previous experiments have shown that a critical thickness of the antiferromagnetic layer is needed to develop the exchange biasing [1,2]; below this thickness, little coupling is observed. To better understand the cause of this critical thickness, we have conducted X-ray diffraction measurements of the structure and chemical order in annealed MnPt spin valves (NiFe/Cu/Co/MnPt) as a function of MnPt film thickness (50-250 Å). Figure 1 shows the in-plane diffraction pattern as a function of MnPt thickness. These data show, first, that the MnPt film texture changes with thickness; while this is interesting; it is probably not relevant to the development of exchange. Second, the data show the chemical order develops between 50 and 100 Å and becomes nearly complete at 150 Å (from the observation of (001) and (110) superstructure peaks and the (220)/(202) peak splitting). Quantification of these data is shown in Figure 2. There is a good correlation between the $L1_0$ chemical order parameter S and the exchange coupling H_{ua} . For PtMn films about 50 Å thick, the MnPt films are not chemically ordered and there is no exchange (the PtMn is not antiferromagnetic). For films thicker than 100 Å, there is nearly complete chemical ordering and the PtMn exchange couples to the Co. However, the coupling does not reach a maximum until 200 Å. Thus, the development of $L1_0$ chemical order is necessary but not sufficient for strong exchange coupling.

Conclusions: These results are similar to those we have found previously for NiMn spin valves. It is interesting that thin films of FePt (which also forms an $L1_0$ phase) show a similar thickness dependence (ref). This suggests a common mechanism, although the precise origin of this is not clear.

References: [1] C Tsang et al., IEEE Trans Magn **30**, 3081 (1994); S Araki et al., J. Appl. Phys. **87**, 5377 (2000).

[2] T Lin, C Tsang, RE Fontana, JK Howard, IEEE Trans Magn **31**, 2585 (1995); T Lin et al., Appl. Phys. Lett. **65**, 1183 (1994).

[3] RFC Farrow et al., J. Appl. Phys. **81**, 4986 (1977).

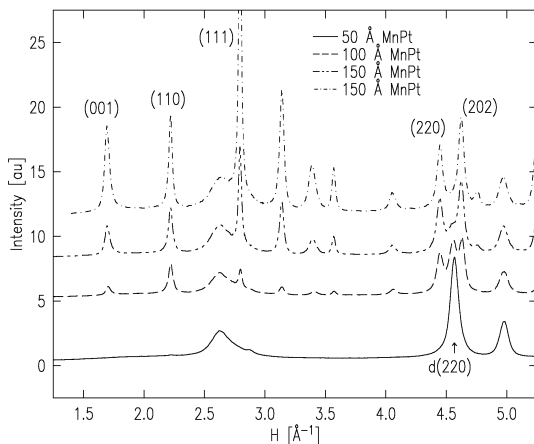


Figure 1. In-plane (grazing incidence) diffraction pattern for NiFe/Cu/Co/MnPt spin valves. Some of the reflections are marked; 'd' refers to the chemically disordered phase, while the other labels are for the ordered phase.

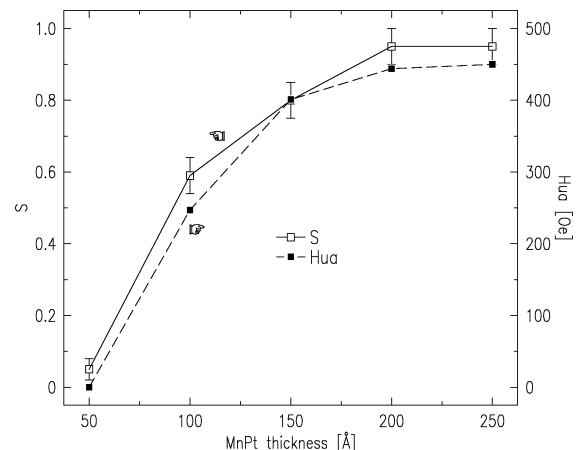


Figure 2. Chemical order (S) and exchange coupling (H_{ua}) as a function of MnPt thickness for NiFe/Cu/Co/MnPt spin valves